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AN INDICATOR MEASURING UNDERLYING ECONOMIC ACTIVITY IN GREECE

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ABSTRACT

Using a state space formulation developed by Stock and Watson and Garratt and Hall we construct an indicator, which then is interpreted as a measure of the underlying economic activity of the Greek economy. The chief novelty of the paper is that the underlying model is calibrated, rather than estimated, using sample information. Our approach is more flexible than the original one, in that it provides the possibility to cope with outlying observations and to evaluate particular shocks affecting the economy using judgmental interventions. The new indicator could be very helpful for short run policy analysis signalling emerging economic problems.

Keywords: Economic Activity; Coincident Indicator; Kalman Filter;
JEL classification: C22; E32

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1. Introduction

The conduct of effective economic policy requires timely information. However, high-frequency data, e.g. monthly data, which are very useful in assessing the current state of the economy, are affected by measurement errors and such data are highly volatile and erratic. In any given month, some indicators may rise, while others may fall, even in related sectors of activity. This makes it difficult to measure and assess the overall conjunctural situation of the economy. The purpose of this paper is to compile an indicator of Greek underlying economic activity, which will summarise the information existing in a range of monthly series and, ultimately, will be able to support the decision-making process. The construction of this indicator is of particular relevance in Greece, where short-run activity indicators are clearly very noisy and affected by a large number of special factors.

The construction of the Greek coincident indicator of underlying economic activity is based on the methodology developed by Stock and Watson (1991). This methodology was later used by Garrat and Hall (1996) as a statistical backdrop in order to construct a coincident indicator for the UK economy.

The intuition underlying the Stock and Watson approach is that movements in many macroeconomic high frequency indicators are driven by a common component that can be identified (i.e., captured) by an unobserved variable[1]. This unobserved variable is then interpreted in abstract terms by Stock and Watson as the "state of the economy". Using the conceptual framework of unobservable variables, Stock and Watson and Garratt and Hall cast their model in a state space form. By applying the Kalman filter, the coincident indicator is derived as the single ''common component'' of all the short-term indicators used. As demonstrated below, this indicator can provide a satisfactory summary estimate of overall economic activity.

In our applications the model is identified using a more flexible scheme which permits some judgmental interventions based on a more thorough examination of data. This scheme is well suited for the Greek case, where short-term conjunctural data are

[1] The Stock and Watson approach is based on the key idea of the single-index model developed by Sargent and Sims (1977) postulating that the comovements of multiple time series arise from a single source.

highly volatile and affected by sector specific shocks not necessarily associated with general economic activity.

The structure of the paper is as follows: The next section contains a brief overview of the literature related to the construction of indicators of economic activity. In section 3, the Stock and Watson model is discussed. Section 4 describes the data entering the analysis and examines their time series properties. Also in this section the model is estimated and the constructed coincident indicator is compared with Eurostat's economic sentiment indicator. Section 5 presents the main results and concludes.

2. The Construction of Indicators: a Brief Survey of the Literature.

The study of business cycle theory and measurement constituted one of the most well- established parts of the early twentieth century economics. The striking regularity of upturns and downturns of economic activity reflected in the simultaneous co-movement of different variables over the cycle was well documented and analysed by authors such as Mitchell and Kuznets, to cite only a few. Defining the business cycle as a pattern seen in a series (Burns and Mitchell (1946)), which is considered to be a good and representative approximation of aggregate economic activity, research on economic fluctuations focuses on a careful examination of these regularities across periods and across countries. A by-product of this research program was the development of a body of methodologies for the constructions of coincident and leading indicators aimed at monitoring and predicting economic fluctuations. The construction of these indicators was initiated at the National Bureau of Economic Research (NBER) by Burns and Mitchell (1946) in a seminal work. The technology developed by Burns and Mitchell became known as the NBER approach.

The NBER approach, as well as other approaches to constructing coincident and leading indicators of the business cycle, relies on the rather abstract concept of the "reference cycle" (Burns and Mitchell (1946)), alternatively called "underlying economic activity" (Garratt and Hall (1996)) and the "state of the economy" (Stock and Watson (Stock and Watson (1991)). According to this concept, economic activity in the broad sense is generally a latent variable and should be estimated by using all available information.

We can broadly distinguish two different[2] methodological approaches in the construction of indicators of economic activity: (1) the non probabilistic (and rather judgmental) NBER approach; and (2) the probabilistic single index (factor) model approach, initiated by Sargent and Sims (1977) and elaborated upon by Stock and Watson (1988) and Garratt and Hall (1996). A more recent vintage of techniques of extracting indexes, developed by Forni *et al* (2000), integrates elements of both approaches in a dynamic principal component framework.

The traditional NBER approach proceeds in two steps: First, an identification of turning points is done separately for each individual series using naked eye methods; then those variables selected and classified as coincident or leading series are averaged in order to construct the indicator. Under this approach, the selection of the series is based on a judgmental and iterative scoring system aimed at evaluating some desirable properties that the candidate series should posses.

The Burns and Mitchell approach is subject to the criticisms that it is highly descriptive in nature and lacks sound statistical foundations. The second approach, developed by Stock and Watson (1988), is based on ideas advanced by Sargent and Sims in their seminal (1977) "FED of Minneapolis" paper, which addressed these criticisms of the Burns and Mitchell approach. While the main ideas of the NBER approach provide the foundation of the Stock and Watson procedure, the latter authors using modern statistical tools, proceed by specifying a formal probability model (a parametric single index model) that can be used to construct coincident and leading indicators. Their indicator is a latent variable derived from this model based on some variables believed to coincide with the "state of the economy". In other words the NBER informal averaging of the selected series is substituted by formal factor analysis.

Subsequently, L. Reichlin and her associates (eg, Altissimo *et al,* 2001) working on a joint project of the Banca d' Italia and CEPR, developed a new methodology to compute coincident and leading indexes using dynamic principal components. Their procedures are applied to estimate business cycle indicators for the euro area. The

[2] The strong similarities between these two approaches are nicely highlighted by Sargent and Sims (1977), using arguments from the famous Koopmans (1949) critique on Burns and Mitchell's work.

Reichlin *et al* methodology, while incorporating many ideas of both the descriptive NBER approach and the formal probability approach, made considerable advances in the domain of 'cleaning' and pre-selection of variables from a very large panel of data. Their work done is contained in several papers, including, Forni *et al* (2000), Altissimo *et al* (2001).

3. Formulation of the Model: The Stock and Watson Approach

In the Stock and Watson (1989) and Hall and Garratt (1996) approach, the problem of the estimation of an indicator measuring underlying economic activity can be formalised as one of the derivation of a single common component from a set of available short-run indicators. This common component is assumed to influence and drive the contemporaneous motion of all indicators entering the analysis. According to Stock and Watson, it identifies the "state of the economy".

Using a state space formulation, these ideas can be formalised as follows. Let us assume that Y(t) is a (mx1) vector of indicators containing some information about the unobservable economic activity indicator, a (1x1) vector denoted as S(t). In this set-up the movement of Y(t) can be described by the following measurement equation:

$$Y(t) = Z*S(t) + d(t) + e(t) \qquad (1)$$

where the Z is the (mx1) parameter matrix containing the weights by which the common component S(t) affects Y(t), d(t) is a vector of deterministic constants, and e(t) is an idiosyncratic term encapsulating all other factors affecting Y(t). The model is completed by embedding the following state equation:

$$S(t) = T*S(t-1) + c(t) + eta(t) \qquad (2)$$

where T is a matrix of parameters, eta(t) is the vector of disturbances in the transition equation, and c(t) is an intercept.

Equations (1) and (2) are defined in terms of first differences (assuming logs, this corresponds to the rate of growth of the series used). Thus, the unobservable S(t) variable is derived in terms of rate of change, since we are mainly interested in the rate of growth of the activity indicator and not its level. The use of first difference is justified by the fact that the series used in our empirical application are all I(1) and they do not co-integrate. In other words, the specification assumes that there are m independent stochastic trends in the data. In their empirical application, Stock and Watson also used rates of change of variables, using a similar argument to justify their approach. However, it should be stressed that this practice does not address one issue raised by Garratt and Hall (1996). In the case that n series are driven by n independent stochastic trends, with no long-run movement in common, the association of any emerging state variable with the level of underlying economic activity is tenuous. Therefore, in this study we will concentrate on the growth rate of economic activity rather than its level. Our *a priori* assumption is that growth rates of a range of economic indicators provide some information pertaining to the growth of the general economy in the short term, but they contain little information about the long term development of the level of economic activity.

The model comprised of equations (1) and (2) is linear in the unobservable variable S(t). By applying the Kalman filtering technique, the parameters of the likelihood function can be estimated and an optimal estimator of S(t) can be constructed. Then, the S(t) can be interpreted as a measure of underlying economic activity. In order to implement the procedure we have to supply a complete specification of the weighting matrix Z as well as a specification of the covariance matrix of eta(t), denoted Q. The numerical specification of the matrices Z and Q, as well as the normalisation rules adopted are based on sample information and are explained in the following section.

4. The implementation of the Model in the Greek case

In the specific application for the Greek economy presented here, the following short-term monthly indicators have been used:

– the industrial output index (NSSG[3]);
– the retail sales volume index (NSSG);
– the volume of new buildings, proxied by the number of permits issued, with a four-month time-lag (NSSG);
– the cement output (NSSG);
– non-oil exports (at constant prices, obtained by deflating the value figures from the Bank of Greece balance of payments statistics with the relevant sub-index of the NSSG Wholesale Price Index);
– travel receipts – i.e., receipts from foreign visitors (at constant prices, obtained by deflating the value figures from the Bank of Greece balance of payments statistics with the NSSG Consumer Price Index); and
– loans to the private sector (at constant prices, after deflating the Bank of Greece data with the NSSG Consumer Price Index).

The choice of these short-run indicators is based on their timely availability, since the main purpose of the construction of the indicator is to provide input for policymaking. Moreover, the indicators comprising the coincident indicator ideally should be strongly contemporaneously correlated with the purported measure of underlying economic activity. In addition, these indicators should be representative of a broad spectrum of activities of the economy. Last, but not least, the variables used reflect our preference to use hard data instead of assessment indicators such as consumers and industrial confidence, etc.

All series are expressed in monthly rates of changes of the corresponding seasonally adjusted monthly level series. They cover the period from February 1990 to April 2003. These series constitute a range of monthly variables which we believe respond to the general level of economic activity. Figures 3-6 highlight the behaviour of the indicators over the more recent period January 1997, April 2003. As is clear from the charts, each indicator behaves very erratically as it is apparently subject to sector specific shocks and noises. Moreover, the charts suggest that a partial and isolated examination of the indicators would provide very limited information for an evaluation of overall economic activity.

[3] NSCG: National Statistical Service of Greece

To demonstrate, consider the following examples: (1) Exports of tourism services should be closely linked with economic activity given the important role which tourism plays in the Greek economy. Yet, tourism receipts displayed erratic behaviour in early 2002 when the monthly growth rate reached a month on month rate of 120%. This outcome probably reflected sector- specific effects such as a rebound and reallocation of international tourism following the September 11 terrorist attacks[4]. (2) Similarly, the behaviour of cement production, which should be a good indicator of overall building activity, is highly erratic with growth rates occasionally above 20%. The other indicators also display similar erratic movements. Clearly, while there may be some useful information in these series, the overall erratic noise is so large that individually they are of little use.

In addition to the main monthly series presented above, an implicitly-calculated monthly GDP growth rate has been added to the short-term indicators. This monthly rate, which is constant during each calendar year, is calculated using the inverted compound formula (1+g)*(1/12), where g is the annual GDP growth rate. In other words, if the implied monthly GDP growth rate is successively applied to the level of last year's GDP, it gives a sequence of monthly GDP flows which are cumulatively equal to the GDP flow of the current year. In order to eliminate any break and discontinuity observed in the transition from one calendar year to another (as annual GDP rates differ from year to year), the series has been smoothed by using a seven-month moving average.

The monthly GDP growth rate plays a key-identifying role in the compilation of the indicator because it is a reference variable that can be used to evaluate the relative weight of all the other highly-volatile indicators in the determination of the overall indicator. It is important to point out that the model outlined in (1) and (2) cannot be estimated without a restriction on the Z matrix; unless Z is fixed, the scale of the indicator variable cannot be determined. Any arbitrary scaling for the Z matrix will be offset simply by a rescaling of the indicator. Our task, therefore, is to impose a restriction on Z, which will make it easy to interpret the index produced. This amounts to normalising one element of the Z matrix to equal unity. This normalisation has the

[4] A change in the methodology in the compilation of the balance of payments statistics occurring at this time also probably affected (to some extent) the behaviour of the series of tourism receipts.

effect of scaling the indicator to have the same overall volatility as that corresponding measured variable. Thus, if we normalised on exports of tourism, we would occasionally obtain growth rates as high as 120% for the index, though the real economy would not be growing at 120%. By normalising on the growth rate of annualised GDP, we can give the growth of the index a natural interpretation, one which is much easier to understand.

GDP was chosen as a reference variable because it is the best single proxy of overall economic activity. Moreover, the variance and mean of GDP growth rates over the sample period are relatively small in comparison with the corresponding summary statistics of the short-term indicators. The measure of overall economic activity should, being a summary measure, exhibit low volatility. Technically, these effects are taken into account in the compilation of the indicator by imposing restrictions, ie by an appropriate weighting of the relevant matrices Z and Q of the estimation system (equations 1 and 2).

The elements of the Z matrix are calculated as the ratio of the sample mean of each variable expressed in monthly changes relative to the sample mean of the monthly GDP growth rate. The specification of the Q matrix is given in a similar manner, ie each diagonal element of the matrix is the ratio of the sample variance of the growth rate of each respective variable relative to the sample variance of the GDP growth rate.

The imposition of these restrictions, which are based on sample information, helps to identify the system, providing the possibility of enlarging the set of short-run indicator, and facilitates the accrual of information. In addition, these restrictions leave room for judgmental interventions which reduce the effect of sharp changes in the short-term indicators on the coincident indicator. On the basis of historical experience concerning changes in short-term indicators and in GDP, such changes are not reflected in changes in overall economic activity.

One possible method of estimation of the other elements of the Z and Q matrices is maximum likelihood. We do not think this technique would be appropriate in the present case for the following reason. The objective of maximum likelihood is to produce a set of parameter estimates for Z and Q, which produce the smallest weighted prediction errors for the measured indicator variables. Yet, our objective is to filter out the noise from these variables rather than to simply produce a good fit of the noise. We, therefore, believe that, in this context, maximum likelihood would do the wrong thing. We can proceed in a better way, in our view, by imposing our priors on this system.

As already mentioned, the formulation of the model in terms of first differences presupposes that all the short-term data that will make up the indicator are I(1) with no co-integrating vector among them. The following Table 1 summarises the results of the Dickey and Fuller (D-F) unit root tests. The (D-F) tests are carried out using auxiliary regressions with two or four lags and a constant term.

The results of the unit root tests clearly suggest that the data are dominated by a stochastic trend. In other words, our hypothesis to formulate the model in terms of first differences seems to be valid and supported by the data. Moreover, in order to provide further support for our empirical approach we need to examine the co-integration properties of the data.

Table 2 reports the results from a Johansen type co-integration analysis of the data set. Again the results support the chosen specification, as the small sample correction does not allow us to reject the null of no cointegration. The test statistics are adjusted for degrees of freedom following Reimers (1992), while the critical values are from Osternwald-Lenum. Given that the small sample adjusted test statistics differ substantially from the respective critical values, we are inclined to believe that our assertion of the non-existence of cointegration in the data is on the safe side.

Application of the Kalman filtering technique allows us to construct the coincident indicator. The results are presented graphically in Figure 1. It shows the monthly (annualised) rates of change in the coincident economic activity indicator during the period February 1990-April 2003. To ensure comparability, the annual GDP growth rate is also shown. It is evident that the coincident indicator closely reflects the developments in economic activity, as measured by GDP, in that period. Comparing the indicator to the Greek economic sentiment indicator compiled by Eurostat, shows that the performance of the new coincident indicator seems satisfactory; it follows the sentiment indicator during the period under consideration quite closely. It does not follow the sharp downturn in sentiment, which occurred during 2000, but neither did actual GDP, (Figure 2).

Table 3 displays a set of diagnostic statistics for the residuals of each component of the measurement equation.According to the standard Q (Ljung and Box) diagnostic statistic for autocorrelation, the null hypothesis of no autocorrelation of up to four and eight lags cannot be accepted at any of the conventional significant levels. However, the autocorrelation dies off quickly. The ARCH tests generally send mixed sings. In particular, the residuals in the volume of new building equation and the non-oil exports of goods equation seem to have significant ARCH effect.

These results suggest a possible extension of the model which would allow us to capture this serial correlation process. This extension would take the following form:

$Y(t) = Z*S(t) + d(t) + R^1 + \beta_1*R^2 + \beta_2*R^3 + \ldots\ldots$

$S(t) = T*S(t-1) + C(t) + eta(t)$

$R^1 = e(t)$

$R^2 = R^1(t-1)$

$R^3 = R^2(t-1)$

…….

where R^q is a set of (qx1) extra state variables. This formulation would add a moving average error process of order q for each of the measurement variables. We leave this extension of the model for further research.

5. Conclusions

In this paper, we have applied a methodology due to Stock and Watson and Garratt and Hall to construct a coincident indicator of economic activity for the Greek economy. The indicator seems to represent a good overall measure of economic activity which exploits the available short-run information in an efficient way. From this perspective, the indicator could be helpful for short-run policy analysis, providing insights for the decision-making process on a monthly basis. The new index may signal emerging economic problems well before annual, or even quarterly, national accounts data are available. The issue of refining and forecasting the short-run movements in this indicator will be the subject of further research.

Appendix, The Kalman Filter

In this section we present the standard Kalman filter equations for the univariate case, following Harvey (1987).

Let

$$Y_t \;=\; \delta' z_t \;+\; \varepsilon_t$$

be the measurement equation, where Y_t is a measured variable, z_t is the state vector of unobserved variables, d is a vector of parameters and e_t ~ NID(0,G_t). The state equation is then given as:

$$z_t \;=\; \Psi z_{t-1} \;+\; \psi$$

where Ψ are parameters and ψ~ NID(0,Q_t), Q_t is sometimes referred to as the hyperparameters

The appropriate Kalman filter prediction equations are given by defining z^*_t as the best estimate of z_t based on information up to t, and P_t as the covariance matrix of the estimate z^*_t, and stating:

$$z^*_{t|t-1} \;=\; \Psi z^*_{t-1}$$

and

$$P_{t|t-1} \;=\; \Psi P_{t-1} \Psi' \;+\; Q_t$$

Once the current observation on y_t becomes available, we can update these estimates using the following equations:

$$z^*_t \;=\; z^*_{t|t-1} \;+\; P_{t|t-1}\delta(Y_t - \delta' z^*_{t|t-1}) / (\delta' P_{t|t-1}\delta + \Gamma_t)$$

and

$$P_t = P_{t|t-1} - P_{t|t-1}\delta\delta' P_{t|t-1} / (\delta' P_{t|t-1}\delta + \Gamma_t)$$

These equations then represent jointly the Kalman filter equations.

If we then define the one-step-ahead prediction errors as,

$$v_t = Y_t - \delta' z^*_{t|t-1}$$

then the concentrated log likelihood function, l can be shown to be proportional to

$$\log(l) = \sum_{t=k}^{T} \log(f_t) + N log(\sum_{t=k}^{T} v_t^2 / N f_t)$$

where f_t = a'$P_{t|t-1}$a + G_t and N=T-k, where k is the number of periods needed to derive estimates of the state vector; that is, the likelihood function can be expressed as a function of the one-step-ahead prediction errors, suitably weighted.

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Table 1: Unit root tests

Variable	Levels	First Differences
Industrial production	-0.081	-10.42
Retail sales Volume	0.769	-6.09
Volume of new Buildings	-1.25	-11.04
Cement output	-2.41	-8.98
Non-oil exports	-1.06	-11.07
Travel receipts	-3.04	-7.77
Loans to the private sector	3.458	-3.518

Table 2: Johansen co-integration tests

R	Asymptotic LR Test	Small Sample LR Test	Critical value 5%
0	193.64	152.56	156.0
1	141.74	111.70	124.24
2	100.11	78.90	94.15
3	62.09	48.93	68.52
4	37.74	29.74	47.21
5	15.04	11.85	29.68
6	5.81	4.52	15.41
7	0.95	0.75	3.76

Table 3: Diagnostic statistics for the residual of the measurement equation

Equation for	Ljung-Box Q(4)	Ljung-Box Q(8)	ARCH (4)
GDP	33.08	38.57	2.27
Industrial Production	23.68	32.01	2.85
Retail Sales	55.47	63.57	17.43
Vol. of new buildings	37.58	39.81	38.64
Cement output	34.05	36.86	20.21
Non-oil exports	31.23	36.62	25.85
Travel receipts	6.39	12.62	4.15
Loans to the private sector	12.86	19.80	0.55

Figure 1

Coincident Indicator of Economic Activity

(annualized rate of growth in %)

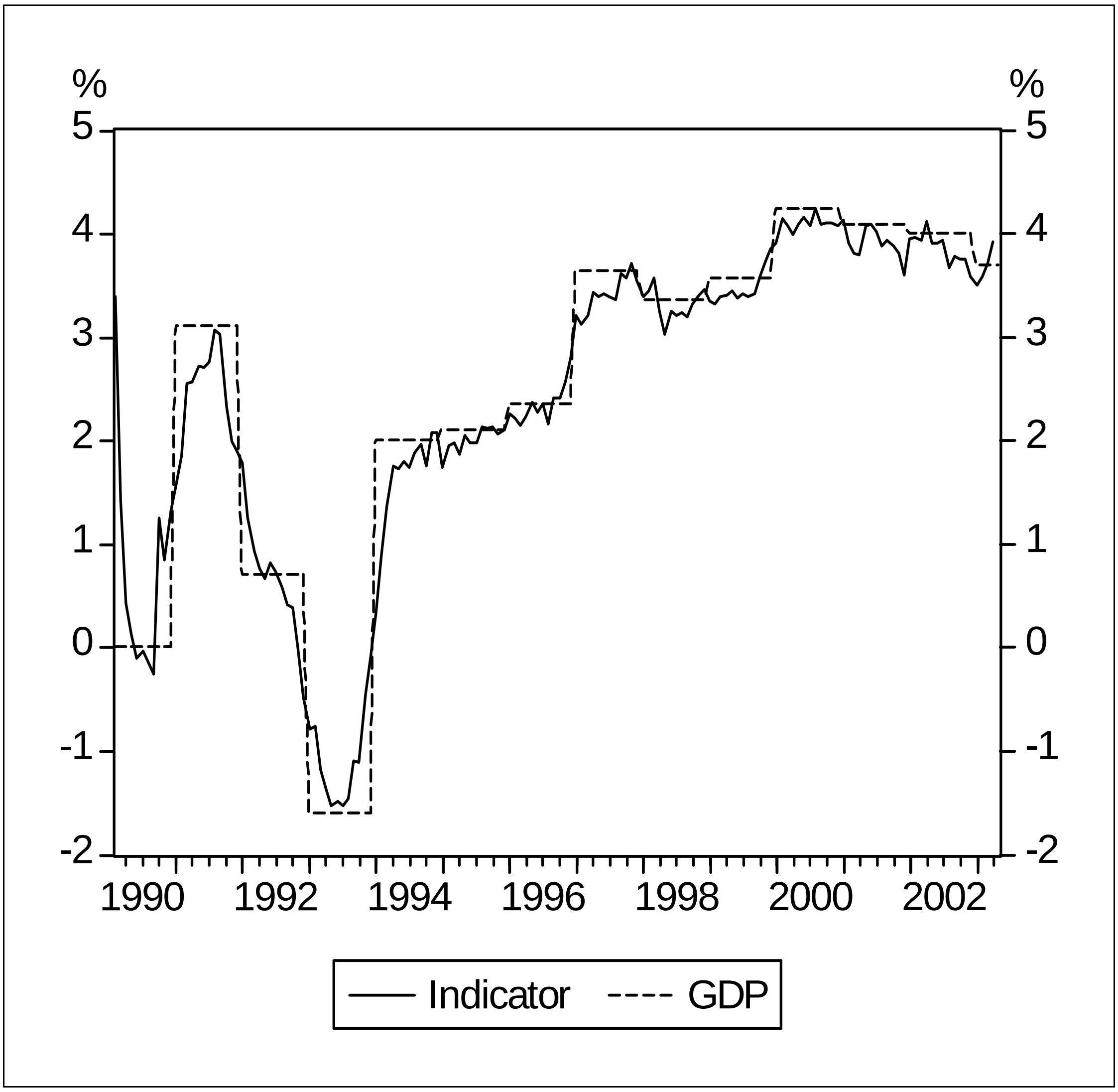


Figure 2

Coincident Indicator and Economic Sentiment Indicator

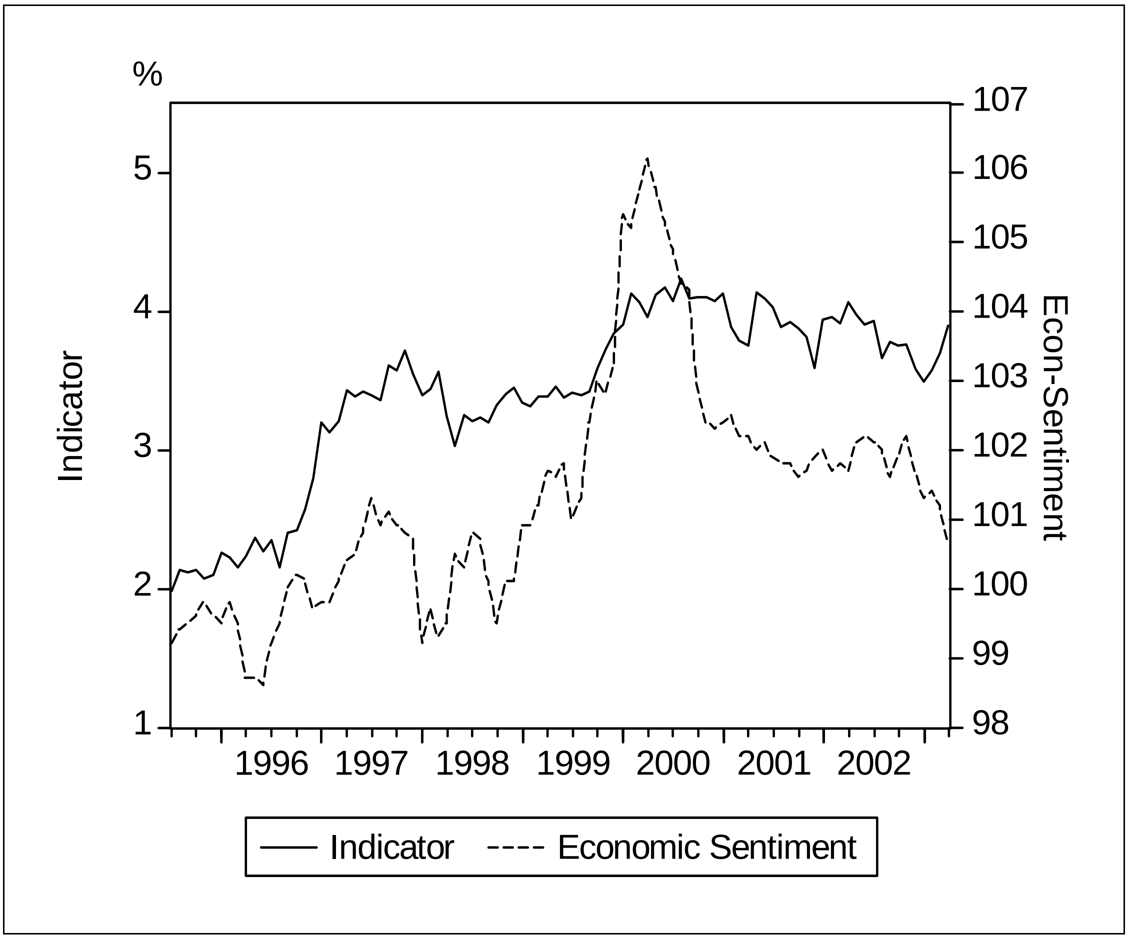
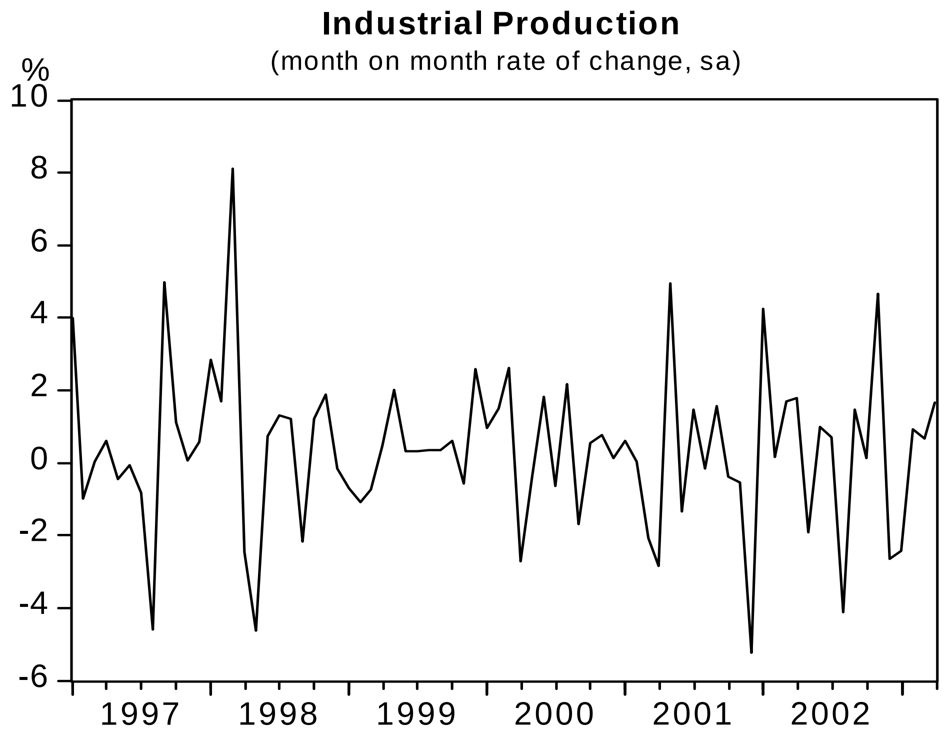


Figure 3


Industrial Production
(month on month rate of change, sa)
%
10
8
6
4
2
0
-2
-4
-6
1997
1998
1999
2000
2001
2002

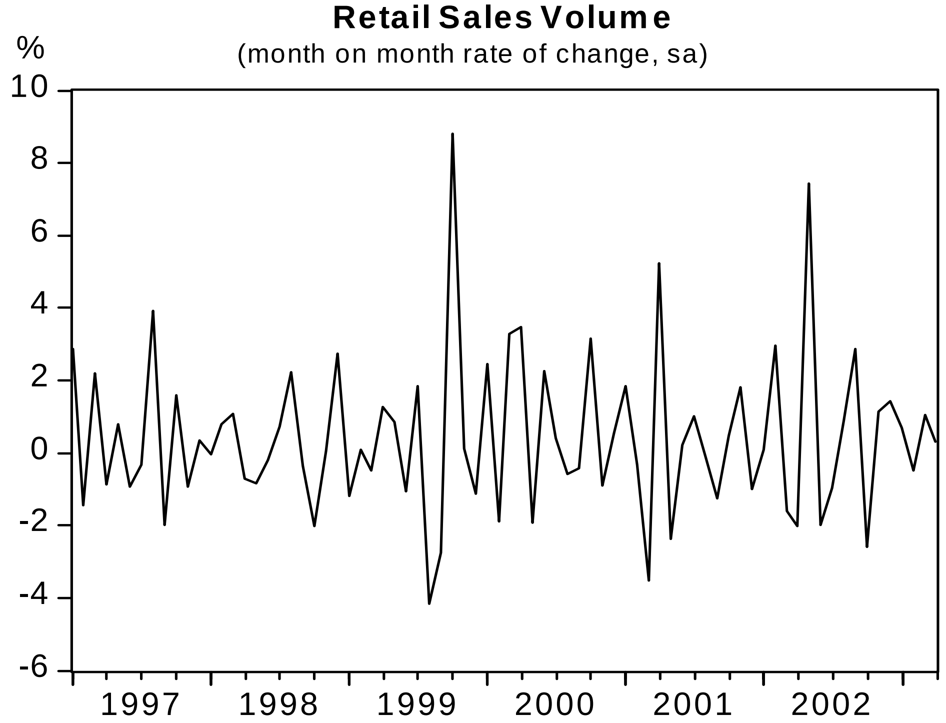
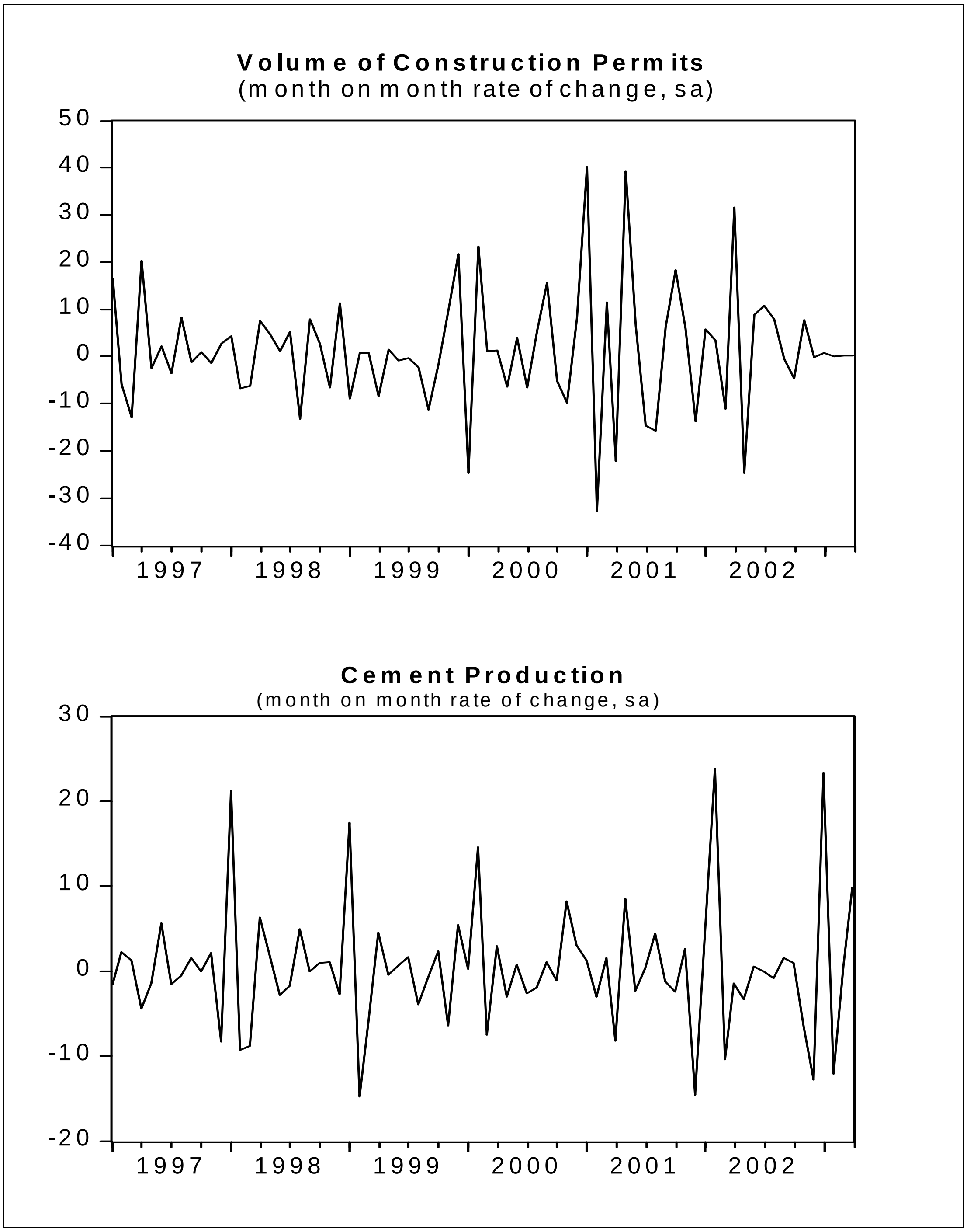

Retail Sales Volume
(month on month rate of change, sa)
%
10
8
6
4
2
0
-2
-4
-6
1997
1998
1999
2000
2001
2002

Figure 4



Volume of Construction Permits
(month on month rate of change, sa)
50
40
30
20
10
0
-10
-20
-30
-40
1997
1998
1999
2000
2001
2002
Cement Production
(month on month rate of change, sa)
30
20
10
0
-10
-20
1997
1998
1999
2000
2001
2002

Figure 5

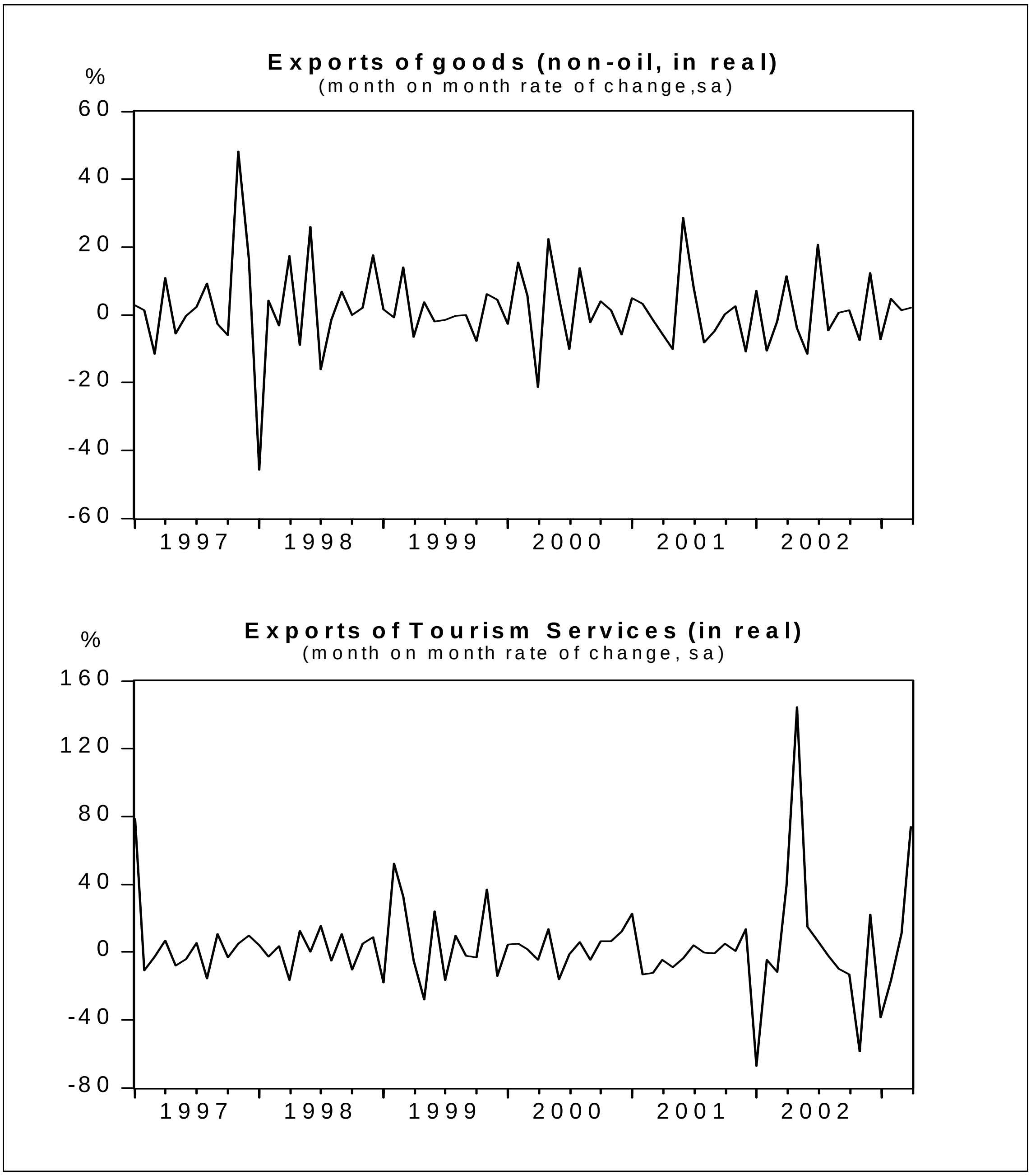
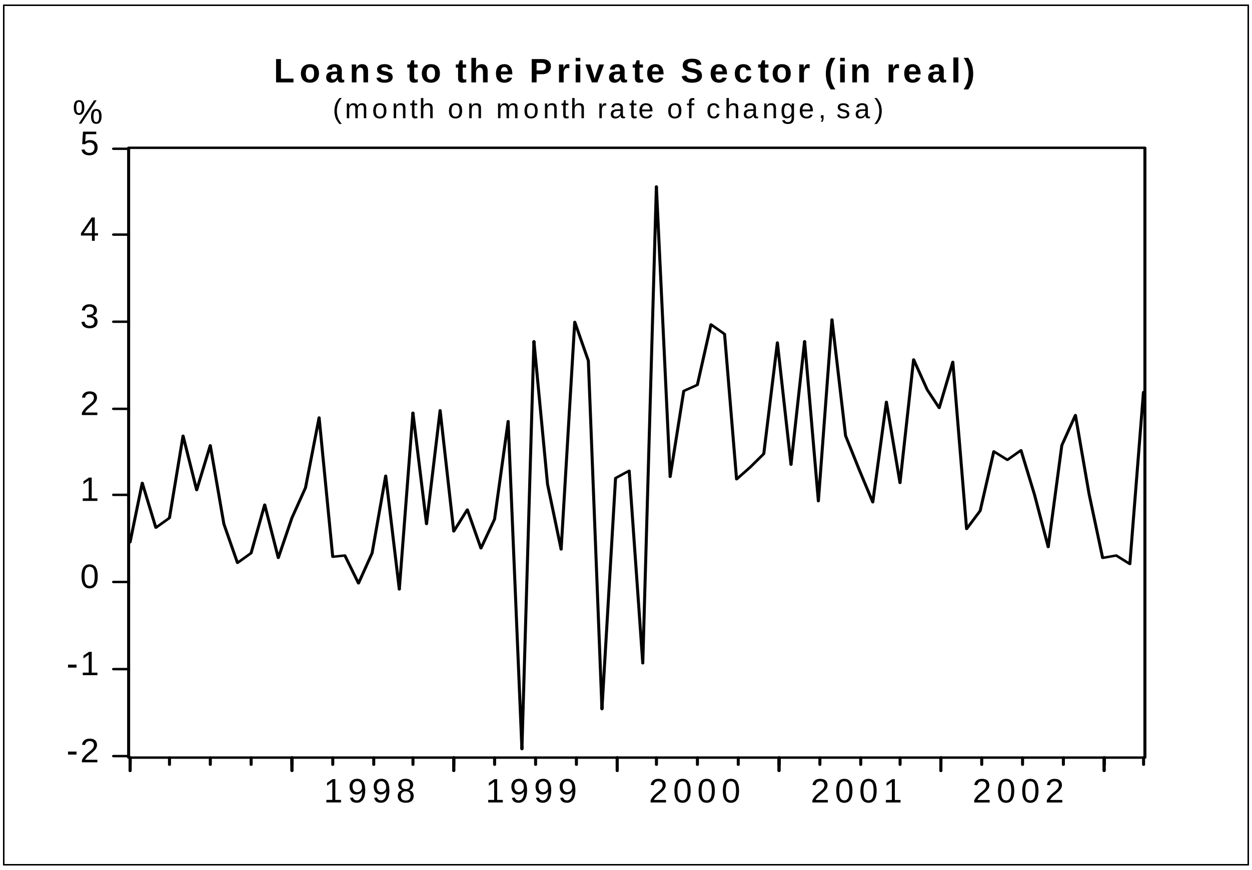

Exports of goods (non-oil, in real)
(month on month rate of change,sa)
%
60
40
20
0
-20
-40
-60
1997
1998
1999
2000
2001
2002
Exports of Tourism Services (in real)
(month on month rate of change, sa)
%
160
120
80
40
0
-40
-80
1997
1998
1999
2000
2001
2002

Figure 6



Loans to the Private Sector (in real)
(month on month rate of change, sa)
%
5
4
3
2
1
0
-1
-2
1998
1999
2000
2001
2002

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